

AD A038009

TECHNICAL REPORT

TR-77-006

RADURIZATION OF FRESH POULTRY

Irradiated Food Products Group
Radiation Preservation of Food Division

Approved for public release;
distribution unlimited.

JULY 1976

UNITED STATES ARMY
NATICK RESEARCH and DEVELOPMENT COMMAND
NATICK, MASSACHUSETTS 01760



Food Engineering Laboratory
FEL-61

Approved for public release; distribution unlimited.

Citation of trade names in this report does not constitute an official indorsement or approval of the use of such items.

Destroy this report when no longer needed. Do not return it to the originator.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM																
1. REPORT NUMBER NATICK/TR-77/006	2. JOINT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER																
4. TITLE (and Subtitle) RADURIZATION OF FRESH POULTRY	5. TYPE OF REPORT & PERIOD COVERED Technical Report																	
7. AUTHOR(s) John J. Howker, Ralph S. Kahan and Eugen Wierbicki	6. PERFORMING ORG. REPORT NUMBER FEL-61																	
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Natick Research and Development Command ATTN: DRXNM-WRI Kansas St., Natick, MA 01760	8. CONTRACT OR GRANT NUMBER(s)																	
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Natick Research and Development Command ATTN: DRXNM-WRI Kansas St., Natick, MA 01760	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 1T762724AH99D 63125411001																	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 33p. 1	12. REPORT DATE July 1976																	
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited	13. NUMBER OF PAGES 30																	
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) 77A-44-001	15. SECURITY CLASS. (of this report) Unclassified																	
18. DECLASSIFICATION/DOWNGRADING SCHEDULE																		
19. SUPPLEMENTARY NOTES																		
20. KEY WORDS (Continue on reverse side if necessary and identify by block number)																		
<table border="0"> <tr> <td>RADURIZATION</td> <td>CHICKENS</td> <td>GAMMA RAYS</td> <td>SALTING</td> </tr> <tr> <td>RADIATION</td> <td>POULTRY</td> <td>IRRADIATION</td> <td>SHELF LIFE</td> </tr> <tr> <td>PRESERVATION</td> <td>BIRDS</td> <td>REFRIGERATION</td> <td></td> </tr> <tr> <td>STORAGE</td> <td>GAMMA IRRADIATION</td> <td>LOW DOSE IRRADIATION</td> <td></td> </tr> </table>			RADURIZATION	CHICKENS	GAMMA RAYS	SALTING	RADIATION	POULTRY	IRRADIATION	SHELF LIFE	PRESERVATION	BIRDS	REFRIGERATION		STORAGE	GAMMA IRRADIATION	LOW DOSE IRRADIATION	
RADURIZATION	CHICKENS	GAMMA RAYS	SALTING															
RADIATION	POULTRY	IRRADIATION	SHELF LIFE															
PRESERVATION	BIRDS	REFRIGERATION																
STORAGE	GAMMA IRRADIATION	LOW DOSE IRRADIATION																
21. ABSTRACT (Continue on reverse side if necessary and identify by block number)																		
<p>The purpose of this investigation was to determine the effect of low dose irradiation and refrigerated storage on the quality of chicken.</p> <p>Fresh eviscerated chicken, with and without salt treatment, were low dose gamma irradiated, stored at -1°, 0°, +1.6° and +4.4° C temperature up to 31 days. At intervals, samples were withdrawn for microbial, physical and</p>																		

DD FORM 1 JAN 73 1473

EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

→ sensory evaluations. The results suggest that a 2.5 kJ/kg irradiation dose and storage at 1.6° C was adequate for a radurized chicken process. The product was free from microbial spoilage and of excellent quality for at least 15 days.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

PREFACE

The investigations reported in this paper were made to determine the effect of low dose irradiation and refrigerated storage on the quality of fresh eviscerated chicken.

Mr. R. S. Kahan, visiting scientist from Soreq Nuclear Research Center, Yavne, Israel, researched the effect of carcass salting (the Kosher processing) and other parameters. Results from these investigations have shown that a good quality radurized chicken that is free from microbial spoilage for at least 15 days can be produced.

These studies were undertaken as a research project by the Irradiated Food Products Group, Radiation Preservation of Food Division, Food Engineering Laboratory, under Project 1Y762724AH99.

ADDITIONAL BY	
DATE	WITH SECTION
NO.	DATE SECTION
ORIGINATOR	
DATE	

A

TABLE OF CONTENTS

	Page
Preface	1
List of Illustrations	4
Introduction	5
Materials and Methods	7
Experimental Results and Discussion	10
Conclusions	14
References	16
Illustrations	18

LIST OF ILLUSTRATIONS

	Page
Figure 1 Effect of storage temperature on TPC of nonirradiated chicken.	18
Figure 2 The effect of salting on TPC during storage at 1.6°C and 4.4°C.	19
Figure 3 The effect of irradiation dose on TPC of chicken carcasses stored at 1.6°C and 4.4°C.	20
Table 1 Effect of storage temperatures on the TPC of nonirradiated chicken	21
Table 2 Effect of salting on TPC of nonirradiated chicken stored at 1.6°C and 4.4°C.	22
Table 3 Effects of irradiation dose on TPC of chicken carcasses stored at 1.6°C and 4.4°C.	23
Table 4 IPC's of radurized whole and halved chicken carcasses stored at 1.6°C.	24
Table 5 Coliform counts of nonirradiated and radurized chicken stored at 1.6°C.	25
Table 6 Faecal streptococci count of nonirradiated and radurized chicken stored at 1.6°C.	26
Table 7 Odor profile of nonirradiated and radurized chicken stored at 1.6°C.	27
Table 8 Appearance of nonirradiated and radurized chicken stored at 1.6°C.	28
Table 9 Preference scores of nonirradiated and radurized chicken stored at 1.6°C.	29
Table 10 Intensity scores of nonirradiated and radurized chicken stored at 1.6°C.	30

RADURIZATION OF FRESH POULTRY

Introduction

Most broiler chickens (8 to 10 weeks old) are marketed as refrigerated, non-frozen carcasses. These broilers are slaughtered, bled, defeathered, eviscerated, washed, and chilled in ice-water tanks to approximately 2° to 4°C. The giblets (neck, gizzard, heart, and liver) are cleaned, wrapped, and placed in the chicken's cavity. The carcasses are packed with crushed ice into crates and shipped to retail outlets. Increasing quantities of tray-packed, cut-up parts and prepackaged individual carcasses in light-gauge polyethylene bags are being used on the commercial markets.

The normal shelf-life of these products depends mainly on the storage temperature. Shelf life is about 4 to 6 days at +4.4°C, 8 days at +1°C, and 10 days at -1°C. Criteria for the limits of shelf-life are the onset of off-odors associated with putridity and skin sliminess, which occur when total microbial counts (TMC) are greater than $10^{6.5}$ to 10^8 per square centimeter. (Elliot and Michener, 1961).¹

The use of ionizing radiation to control the microbial spoilage and increased shelf-life of fresh chicken has been investigated in the United States and in other countries. The irradiation dose levels used were from 1.0 to 10.0 kJ/kg: 1.0 to 3.0 kJ/kg to control spoilage, and 5.0 to 10.0 kJ/kg to eliminate Salmonellae (McGill et al., 1959);²

¹Elliot, R. P. and H. D. Michener, 1961. Microbiological standards and handling codes for chilled and frozen foods. A review. Appl. Microbiol. 9:452.

²McGill, N. J., A. I. Nelson, M. I. Steinberg, and L. L. Kempe, 1959. Gamma ray pasteurization of whole eviscerated chicken. Food Tech. 13:75.

Hannan and Sheppard, 1959;³ Colby et al., 1960;⁴ Thornley et al., 1960;⁵ Thornley, 1963;⁶ Rhodes, 1965;⁷ Mercuri et al., 1966;⁸ Mossel and Degroot, 1965;⁹ Lineweaver, 1966;¹⁰ Previte, 1967;¹¹ Idziak and Incze, 1967¹²).

³Hannan, R. S. and H. J. Sheppard, 1959. Treatment of meats with ionizing radiation. I. Changes in odor, flavor and appearance of chicken meats. *J. Sci. Food Agric.* 10:286.

⁴Colby, B., M. Ingram, H. J. Sheppard, and M. J. Thornley, 1960. Treatment of meats with ionizing radiation. IV. Comparison of the deterioration in quality during storage of eviscerated chicken carcasses treated with chlortetracycline or radiation. *J. Sci. Food Agric.* 11:678.

⁵Thornley, M. J., M. Ingram, and E. M. Barnes, 1960. The effect of antibiotics and irradiation on the *Pseudomonas-Achromobacter* flora in chilled poultry. *J. Appl. Bact.* 23:487.

⁶Thornley, M. J. 1963. Microbiological aspects of the use of radiation for the elimination of *Salmonellae* from foods and feeding stuff. International Atomic Agency Technical Reports. Series No. 22:81.

⁷Rhodes, D. N. 1965. The radiation pasteurization of broiler chicken carcasses. *British Poultry Sci.* 6:265.

⁸Mercuri, A. J., A. W. Kotula, and D. H. Sanders, 1966. Low dose ionizing radiation of tray-packed, cut-up fryer chicken. *Poul. Sci.* 45:1105.

⁹Mossel, D. A. A. and A. P. DeGroot, 1965. The use of pasteurization doses of gamma radiation for the destruction of *Salmonellae* and other *Enterobacteriaceae* in some foods of lower water activity. Radiation Preservation of Foods Public No. 1273. Natl. Acad. Sci. Natl. Res. Council, Washington, DC.

¹⁰Lineweaver, H. 1966. Sensitivity of *Salmonellae* to beta and gamma energy. The destruction of *Salmonellae*. ARS74-37. Western Experiment Station. USDA, Albany, CA.

¹¹Previte, J. J. 1967. Salmonellosis—The problems and potential remedy. *Activities Report.* 19(1): 64.

¹²Idziak, E. S. and K. Incze, 1968. Radiation treatments of foods, I. Radurization of fresh eviscerated poultry. *App. Microbial.*, 16(7): 1961.

Approval of Co-60 radurization of eviscerated poultry packaged in plastic bags has been granted for experimental batches in the USSR (6.0 kJ/kg dose, 4 Jul 66), the Netherlands (3.0 kJ/kg maximum dose, 31 Dec 71) and test batches in Canada for Salmonellae control (7.0 kJ/kg maximum dose, 20 Jun 73).

The purpose of this investigation was to establish the minimum dose of irradiation and storage temperature for optimum shelf-life of fresh chicken carcasses or cut-up parts. The investigation included microbiology, physical observations, sensory evaluations, and effects of salting on stored chicken.

Materials and Methods

Materials. Fresh killed 0.9 to 1.4 kg, eviscerated chickens were obtained from USDA-inspected processing plants in greater Boston, Massachusetts or Willimantic, Connecticut. The chickens were transported in ice-packed insulated cartons to the US Army Natick Research and Development Command, Natick, MA within 5 hours post-slaughter. Each carcass was individually packaged in a 2-mil (0.0508-mm) medium density polyethylene bag, closed by twisting, and tied with string. Other chicken samples included: halved carcasses, chicken parts, or giblets arranged on fiber or plastic trays and overwrapped with polyethylene film.

Irradiation Processing. Prior to irradiation, the individually bagged chickens were either placed in #10 cans containing ice or in a temperature-controlled carrier. The chickens were irradiated using Co-60 facilities at US Army Natick Research and Development Command, Natick, MA and Marine Products Development Irradiator, Gloucester, MA. Six

irradiation doses were used: 1.3, 2.0, 2.5, 2.8, 5.0, and 5.6 kJ/kg. Dosimetry using Cu-Fe solutions showed that the absorbed dose in various parts of the carcass was within $\pm 10\%$ of the mean dose. The mean dose was approximately the same as that measured in the air cavity at the center of the carcass. Chicken carcass temperatures following irradiation were 2°C to 4°C. Irradiation took place within 24 hours post slaughter. After irradiation, the chickens were stored at temperatures of -1°C, 0°C, 1.6°C, and 4.4°C.

Microbiology. Microbiological examinations consisted of total counts and the presence of coliform and faecal streptococci. Preliminary experiments showed that the area beneath the wing and at the junction of the leg and thigh had higher plate counts. A sterile aluminum foil template with a 6.3-square-cm aperture was placed on these areas. Calcium alginate swabs, moistured with 0.1% peptone water, were used to swab the chicken. The swab tip was severed into a 10-ml tube of peptone water. The peptone tubes were agitated with a Vortex mixer and serial dilutions made as required. Quadruplicate Difco Heart-Infusion agar plates were surface-streaked with 0.1-ml quantity. Duplicate plates were incubated at 5°C for 21 to 28 days for psychrophilic growth and at 21°C for 5 days for mesophilic growth. Rodac plates and the method by Powers (1965)¹³ were used for the determination of coliform and faecal streptococci bacteria.

¹³Powers, E. M. 1965. Microbial profile of laminar flow clean rooms. NASA Rpt. No. X-600-65-308, Goddard Space Flight Center, Greenbelt, MD.

Evaluations, Physical. The irradiated and nonirradiated chickens were examined for carcass odor at the breast and vent, skin sliminess, overall appearance, and breast and thigh meat color.

Evaluation, Sensory. The whole chicken was wrapped in aluminum foil and oven-roasted at 177°C. Samples of dark and white meat were separately evaluated by an eight-member technological panel for discoloration, off odor, irradiation flavor, off flavor, mushiness, and friability. The following intensity ratings were used: 1 - none; 2 - trace; 3 - slight; 4 - below moderate; 5 - moderate; 6 - above moderate; 7 - strong; 8 - very strong; and 9 - extreme. The samples were also evaluated for preference using a 9-point hedonic scale according to Peryam and Pilgrim (1957).¹⁴ A hedonic rating of 5 or above indicates an acceptable product.

¹⁴Peryam, D. R. and F. J. Pilgrim, 1957. Hedonic scale methods for measuring food preferences. Food Technol. 11, Suppl. p. 9.

Experimental Results and Discussion

The effect of storage temperature on shelf-life (total plate count) of nonirradiated chicken. Fresh chicken was stored at -1°C , $+1.6^{\circ}\text{C}$, and 4.4°C temperature. The rate of microbial multiplication at $+1.6^{\circ}\text{C}$ was slightly slower than at 4.4°C (Table 1 and Figure 1). Microbial growth at -1°C exhibited a distinct 8-day lag before a logarithmic growth phase. Using a total plate count of 10^6 to $10^8/\text{cm}^2$ as a base line for spoilage, the shelf-life of chicken stored at 4.4°C was approximately 6 days, at 1.6°C , 8 days, and at -1°C , 14 days. This data is in general agreement with other workers (Elliot and Michener, 1965¹⁵).

The effect of carcass salting on shelf-life (TPC) of nonirradiated chicken. In addition to other procedures, the Kosher processing of fresh chicken includes a dry salt coating of the carcass and holding for 30-45 minutes before final washing and cooling. This procedure lowers the spoilage bacteria population and increases the shelf-life.

USDA inspected, Kosher processed, 0.9 to 1.4 kg chickens were obtained from a Willimantic, Connecticut packer. The effect of Kosher processing and storage at 1.6°C and 4.4°C on microbial count is shown in Table 2 and Figure 2. The TPC of salt-treated carcasses were one log count less than controls during 15 days storage at 1.6°C and 9 days at 4.4°C . The carcasses had 1 to 3 days additional shelf-life as judged by the onset of off-odors and sliminess.

¹⁵Elliot, R. P. and H. D. Michener. Factors affecting the growth of psychrophilic microorganisms in food. Technical Bulletin No. 1320. US Department of Agriculture, Washington, DC 1965.

The effects of irradiation dose and storage temperatures on the shelf-life (TPC) of chicken carcasses. Fresh chicken stored at 4.4°C and irradiated at $5.6 \text{ kJ/kg} \pm 5\%$ had a TPC at 21 days equivalent to that of fresh killed chicken (Figure 3). The TPC was only tenfold higher after 29 days storage. Irradiation doses of 1.3 and 2.8 kJ/kg maintained a fresh chicken TPC for approximately 9 and 14 days, respectively; but the counts rapidly increased during the following 10 days. Irradiation at a dose of 1.3 kJ/kg and storage at 1.6°C was effective in maintaining a fresh chicken count for 16 days and the 2.8 kJ/kg dose for 21 days. It was noted that irradiation at the three doses and storage at 1.6 or 4.4°C increased the chicken shelf-life greater than a 3-day period. Therefore, a process of salting and irradiation would not beneficially increase the storage period as irradiation alone sufficiently decreases the microbial load.

The effects of irradiation dose and storage on the shelf-life (TPC) of whole and halved chicken carcasses. Whole, fresh, eviscerated chicken carcasses were placed on paperboard trays and overwrapped with polyethylene film; halved carcasses were similarly prepared. The trays were irradiated with 1.3, 2.0, and 2.8 kJ/kg, and inspected for appearance and TPC after 17 and 29 days storage at 1.6°C . The results (Table 4) indicate that the cut halves were as microbiologically clean as the whole carcasses. This is in agreement with the work of Mercuri (1966).⁸

The effects of irradiation dose and storage on the coliform and faecal streptococci count of chicken carcasses. Tables 5 and 6 are coliform and faecal streptococci counts of nonirradiated and radurized stored chicken carcasses. The tables indicate that the 2.0, 2.5, and 5.0 kJ/kg doses were sufficient to practically eliminate the coliform and faecal streptococci on chicken carcasses skin, which cannot proliferate at 1.6°C storage even if they survive.

The incidence of salmonellae on fresh chicken carcasses is reported to be less than one per gram for USDA inspected plants (Surkiewicz et al., 1969).¹⁶ Both coliform and faecal streptococci have been associated with outbreaks of food poisoning (Mountney, 1966).¹⁷ Mossel et al., (1968)¹⁸ researched frozen poultry, and the relative frequency was: *E. Coli* > *Proteus* sp. >> *Klebsilla* >>> *Salmonellae*; and that *Salmonellae* comprised less than 1% of these organisms. Thus a determination of the coliform and/or faecal streptococci count would supply indirect information on *Salmonellae* contamination. The 2.0 to 2.5 kJ/kg. dose substantially reduces the population of organisms with public health significance and there was no outgrowth of survivors during 3 weeks storage at 1.6°C.

¹⁶ Surkiewicz, B. F., R. W. Johnston, A. B. Moran, and G. W. Krumm, 1969. A bacteriological survey of chicken eviscerating plants. *Food Tech.* 23:1066.

¹⁷ Mountney, G. J., 1966. *Poultry Products Technology*, AVI Publ. Co., Westport, CN.

¹⁸ Mossel, D. A. A., V. Von Schothorst, and E. H. Kampelmacher, 1968. Prospects for the salmonella eradication of some foods and feeds. Elimination of harmful organisms from food and feed by irradiation. 43-57. IAEA, Vienna.

The effect of radurization on the physical characteristics of chicken. The odor of the nonirradiated chicken carcasses stored at 1.6°C deteriorated from a fresh chicken odor to no odor after 8 days, a slight off-odor at 11 days, and increasing putrid odor after 15 days (Table 7). The radurized carcasses had a slight irradiation odor that dissipates after 4 days storage. A chicken odor then predominates for approximately 18 days when a stale old chicken, sometimes sour odor, replaces it.

The nonirradiated chicken stored at 1.6°C had no skin or viscera discoloration for 8 days. A dull grayish skin color then developed signifying the onset of decomposition (Table 8). This grayish appearance correlated with the loss of the characteristic chicken odor. Discoloration increased with storage time, denoting further decomposition. The radurized chicken had a slight pink discoloration of the breast (white) meat due to irradiation. The pink color was more pronounced in the 5.0 kJ/kg irradiated carcasses. This discoloration was not discernable in the dark (thigh) meat. A dull, brown discoloration of the viscera and skin blanching took place after 18 to 22 days storage, corresponding to the detection of the stale old chicken odor.

The preceeding observation emphasizes the effects of radurization of chicken. Due to the irradiation induced bacterial reduction, the TPC of radurized chicken stored 15 to 18 days at 1.6°C were equivalent to that of freshly slaughtered chicken. However, the quality of radurized chicken deteriorates during storage due to enzymatic activity,

and the shelf-life of high quality carcasses was less than that for microbial spoilage; thus the TPC cannot be used as an index of quality for radurized chicken.

The effect of radurization on the sensory scores of chicken.

Nonirradiated and radurized chicken were oven-roasted at 177°C, and the white and dark meat were separately evaluated. Nonirradiated samples stored longer than eleven days were not tasted. The preference scores in Table 9 indicated all samples were in the acceptable range, and the 2.5 kJ/kg samples were slightly superior to the 5.0 kJ/kg samples. The quality of stored, irradiated chicken was similar to fresh chicken for 15 days and was acceptable to 30 days. However, the taste panels judged the cooked meat, not carcass appearance or cooking quality. Unpleasant odors were released during roasting of chicken stored longer than 20 days, and overall general appearance of the unroasted carcass was questionable.

The meat samples were evaluated for intensity of irradiation flavor and mushiness (Table 10). No irradiation flavor was detected. A trace intensity for mushiness was noted in the 5.0 kJ/kg irradiated dark meat.

Conclusions

Based on these observations, it was suggested that a 2.5 kJ/kg irradiation dose and storage at 1.6°C was sufficient for a radurized chicken process. The resulting chicken was free from microbial spoilage and was of excellent quality for at least fifteen days. The 2.5 kJ/kg irradiation dose has the following advantages:

sufficient microbial reduction; death or growth inhibition of coliform and faecal streptococci; less irradiation carcass odor and discoloration; and lower costs. The Kosher processed nonirradiated chicken showed 1 to 3 days additional shelf-life as a result of about one log lower microbial count in comparison with the non-Kosher industrially processed fresh chicken.

REFERENCES

1. Elliot, R. P. and H. D. Michener 1961. Microbiological standards and handling codes for chilled and frozen foods. A review. *Appl. Microbiol.* 9:452.
2. McGill, N. J., A. I. Nelson, M. I. Steinberg, and L. L. Kempe 1959. Gamma ray pasteurization of whole eviscerated chicken. *Food Tech.* 13:75.
3. Hannan, R. S. and H. J. Sheppard 1959. Treatment of meats with ionizing radiation. I. Changes in odor, flavor and appearance of chicken meats. *J. Sci. Food Agric.* 10:286.
4. Colby, B., M. Ingram, H. J. Sheppard, and M. J. Thornley 1960. Treatment of meats with ionizing radiation. IV. Comparison of the deterioration in quality during storage of eviscerated chicken carcasses treated with chlorotetracycline or radiation. *J. Sci. Food Agric.* 11:678.
5. Thornley, M. J., M. Ingram, and E. M. Barnes 1960. The effect of antibiotics and irradiation on the *Pseudomonas-Achromobacter* flora in chilled poultry. *J. Appl. Bact.* 23:487.
6. Thornley, M. J. 1963. Microbiological aspects of the use of radiation for the elimination of *Salmonellae* from foods and feeding stuffs. International Atomic Agency Technical Reports. Series No. 22:81.
7. Rhodes, D. N. 1965. The radiation pasteurization of broiler chicken carcasses. *British Poultry Sci.* 6:265.
8. Mercuri, A. J., A. W. Kotula, and D. H. Sanders 1966. Low-dose ionizing radiation of tray-packed, cut-up fryer chickens. *Poul. Sci.* 45:1105.
9. Mossel, D. A. A. and A. P. DeGrott 1965. The use of pasteurization doses of gamma radiation for the destruction of *Salmonellae* and other *Enterobacteriaceae* in some foods of lower water activity. Radiation Preservation of Foods. Publication No. 1273. Natl. Acad. Sciences, Natl. Res. Council, Washington, DC.
10. Lineweaver, H. 1966. Sensitivity of *Salmonellae* to beta and gamma energy. The destruction of *Salmonellae*. ARS74-37. Western Experiment Station. USDA, Albany, CA.
11. Previte, J. J. 1967. Salmonellosis - The problems and potential remedy. *Activities Report.* 19(1): 64.

12. Idziak, E. S. and K. Incze 1968. Radiation treatment of foods.
I. Radurization of fresh eviscerated poultry. Appl. Microbiol.,
16 (7): 1968.
13. Powers, E. M. 1965. Microbial profile of laminar flow clean
rooms. NASA Rpt. No. X-600-65-308, Goddard Space Flight
Center, Greenbelt, MD.
14. Peryam, D. R. and F. J. Pilgrim 1957. Hedionic scale methods
for measuring food preference. Food Technol. 11, Suppl. p. 9.
15. Elliot, R. P. and H. D. Michener. Factors affecting the growth
of psychrophilic microorganisms in food. Technical Bulletin
No. 1320. US Department of Agriculture, Washington, DC 1945.
16. Surkiewicz, B. F., R. W. Johnston, A. B. Moran, and G. W. Krumm
1969. A bacteriological survey of chicken eviscerating
plants. Food Tech. 23:1066.
17. Mountney, G. J. 1966. Poultry Products Technology, AVI Publ. Co.,
Westport, CN.
18. Mossel, D. A. A., V. von Schothorst, and E. H. Kampelmacher 1968.
Prospects for the salmonella eradication of some foods and
feeds. Elimination of harmful organisms from food and feed
by irradiation. 43-57. IAEA, Vienna.

FIGURE 1

EFFECT OF STORAGE TEMPERATURE ON TPC
OF NONIRRADIATED CHICKEN.

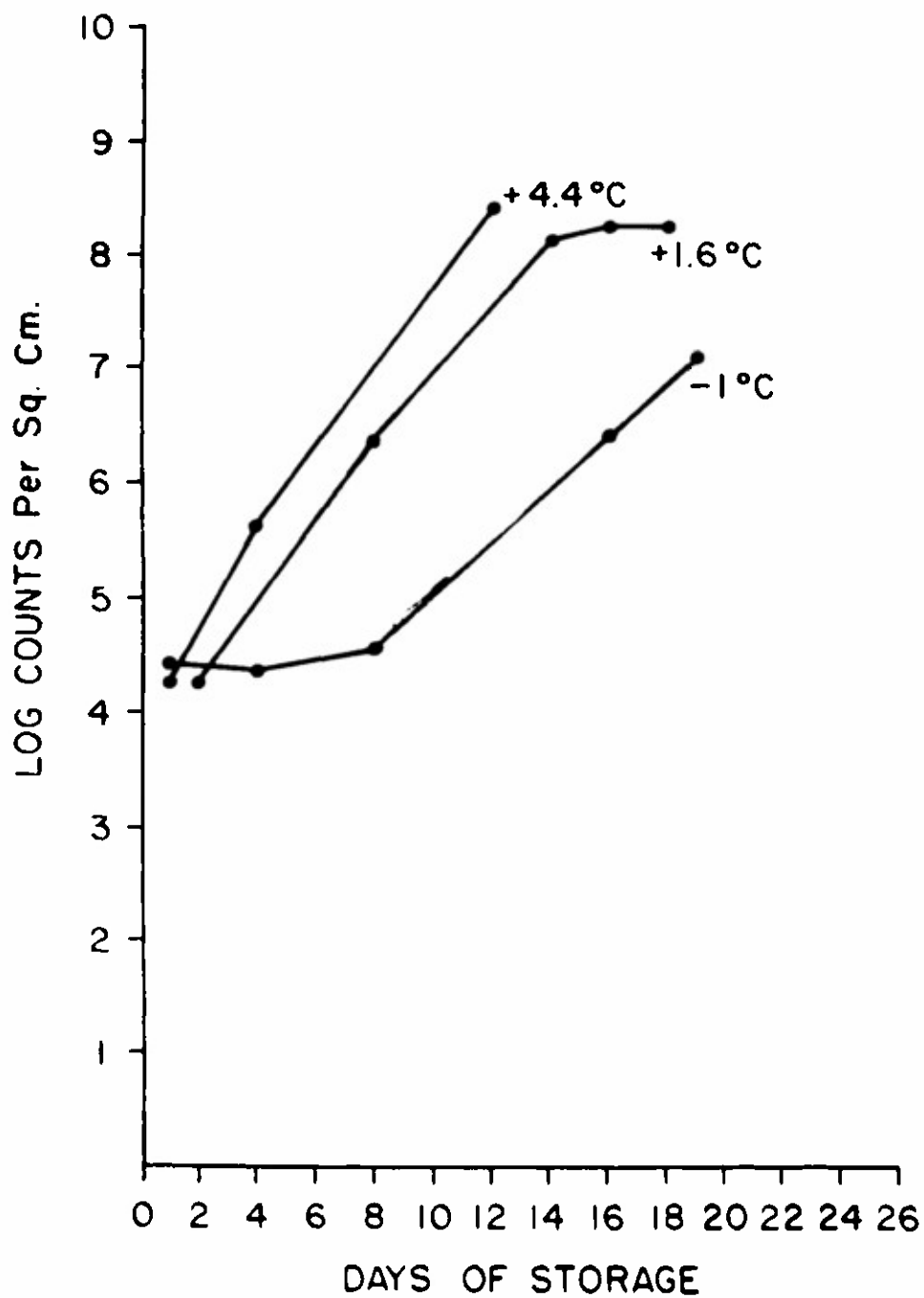


FIGURE 2

EFFECT OF SALTING ON TPC DURING STORAGE AT 1.6°C and 4.4°C.

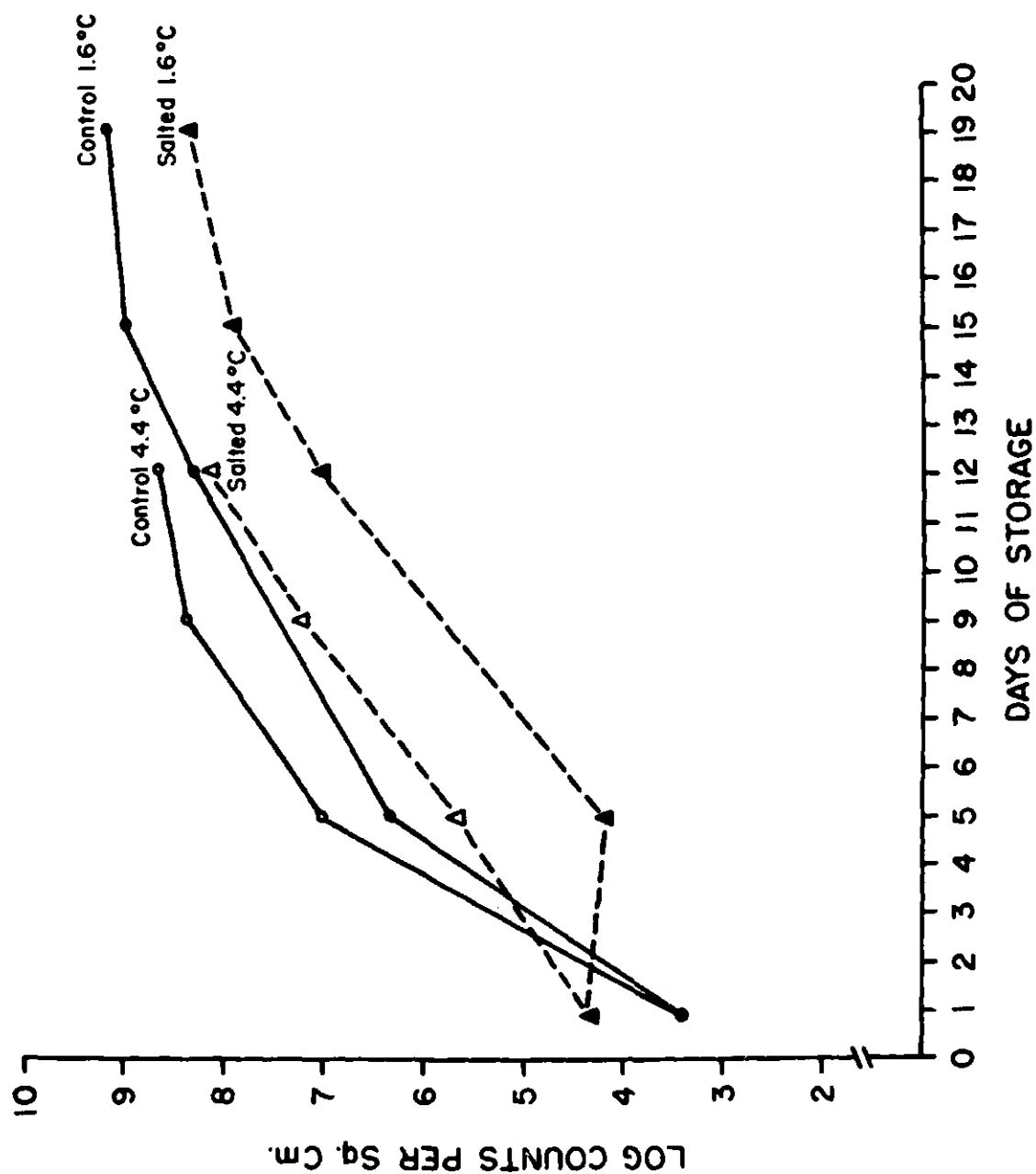


FIGURE 3

EFFECT OF IRRADIATION DOSE ON TPC OF CHICKEN
CARCASSES STORED AT 1.6°C and 4.4°C.

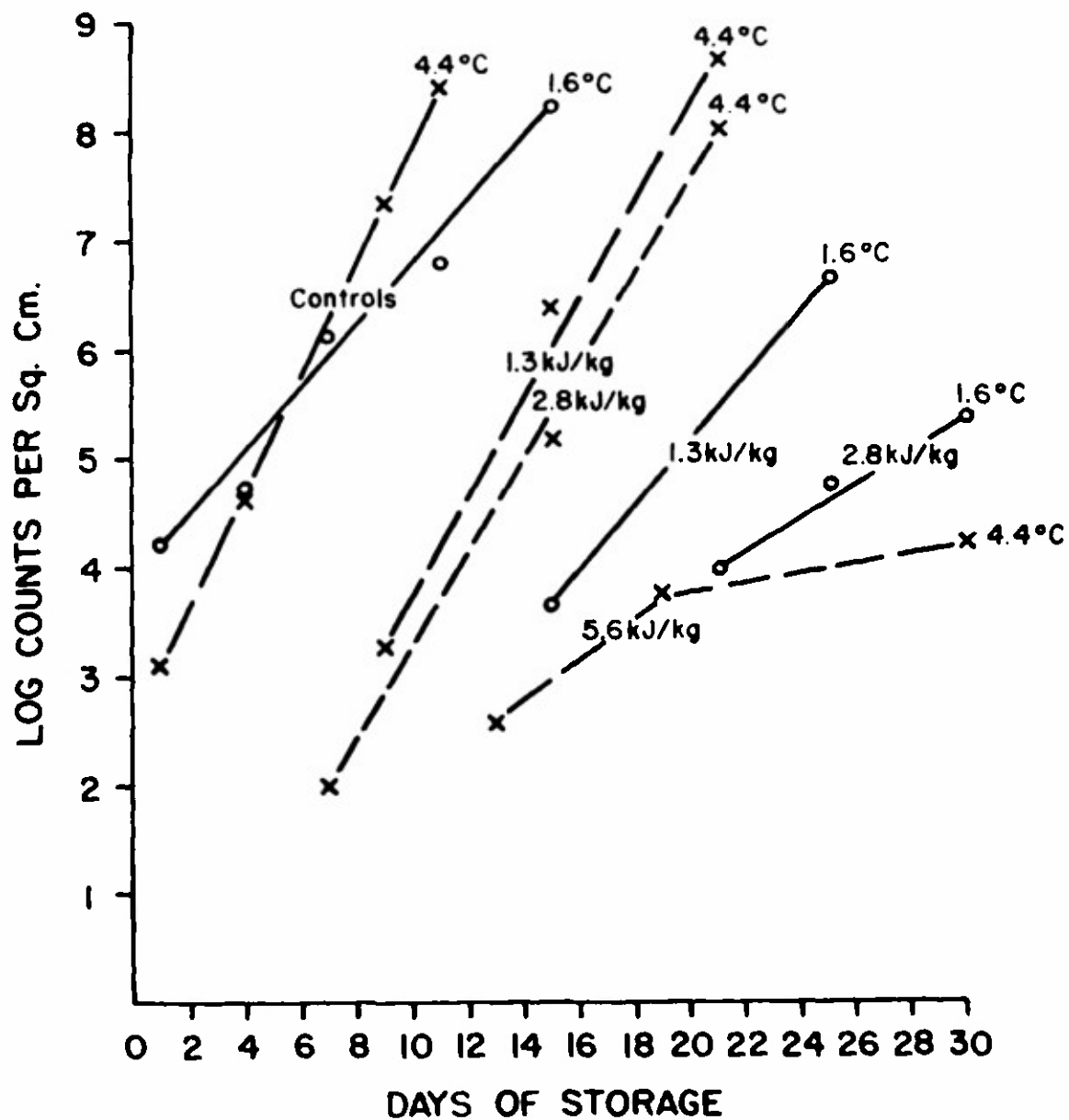


Table 1
Effect of storage temperatures on the TPC*
of nonirradiated chicken

Days Stored	<u>Storage Temperature ($^{\circ}\text{C}$)</u>		
	-1° to 0°	$+1.6^{\circ}$	4.4°
0.5 - 1	4.8×10^4	--	2.9×10^4
2	--	2.9×10^4	--
3	--	--	--
4 - 5	4.0×10^4	--	6.5×10^5
7 - 8	6.0×10^4	4.0×10^6	--
9 - 10	--	--	3.9×10^7
12 - 13	--	--	4.1×10^8
14	--	1.7×10^8	--
15 - 16	4.8×10^6	2.6×10^8	--
18 - 19	1.5×10^7	2.6×10^8	--

* TPC per sq cm

Table 2
Effect of salting on TPC* of nonirradiated chicken
stored at 1.6° and 4.4°C

Days Stored	<u>Storage Temperature</u>			
	1.6°C		4.4°C	
	Controls	Salted	Controls	Salted
1	4.2×10^3	3.9×10^4	4.2×10^3	3.9×10^4
5	3.1×10^6	2.9×10^4	1.0×10^7	6.5×10^5
9	--	--	3.0×10^8	2.2×10^7
12	2.9×10^8	1.0×10^7	6.2×10^8	1.5×10^8
15	9.9×10^8	9.3×10^7	--	--
19	1.6×10^9	3.5×10^8	--	--

*TPC per sq cm

Table 3
Effects of irradiation dose on TPC* of chicken
carcasses stored at 1.6°C and 4.4°C

Days Stored	Control		Irradiation Dose			
	1.6°C	4.4°C	1.3 kJ/kg 1.6°C	4.4°C	1.6°C	2.8 kJ/kg 4.4°C
1	2.0 x 10 ⁴	1.2 x 10 ³				< 1 x 10 ²
4	7.6 x 10 ⁴	6.5 x 10 ⁴				< 1 x 10 ²
7	1.3 x 10 ⁶					
9		3.9 x 10 ⁸		2.8 x 10 ³		
11	7.8 x 10 ⁶	4.1 x 10 ⁷				
13						
15	2.6 x 10 ⁸		6.6 x 10 ³	4.0 x 10 ⁶		2.0 x 10 ⁵
17	2.6 x 10 ⁸					
19						
21				6.3 x 10 ⁸	1.0 x 10 ⁴	1.0 x 10 ⁸
23					8.2 x 10 ⁴	
25			6.9 x 10 ⁶			
27			5.6 x 10 ⁶		4.1 x 10 ⁵	
29						2.5 x 10 ⁴

* TPC per sq cm

Table 4

*
TPC's of radurized whole and
halved chicken carcasses stored at 1.6°C

<u>Dose kJ/kg</u>	<u>17 days</u>		<u>29 days</u>	
	<u>Whole</u>	<u>Halves</u>	<u>Whole</u>	<u>Halves</u>
1.3	1.0×10^4	$< 10^3$	1.3×10^6	3.5×10^4
2.0	$< 10^3$	$< 10^3$	3.1×10^4	8.0×10^3
2.8	$< 10^3$	$< 10^3$	1.2×10^3	9.2×10^3

* TPC per sq cm

Table 5

Coliform counts* of nonirradiated and radurized
chicken stored at 1.6°C

<u>Days</u> <u>Stored</u>	<u>Irradiation Dose</u>			
	<u>Nonirradiated</u>	<u>2.0 kJ/kg**</u>	<u>2.5 kJ/kg**</u>	<u>5.0 kJ/kg**</u>
0	<10	—	<1	<1
3	<10	<1	—	—
4	21	—	<1	<1
8	<10	<1	<1	<1
11	<1	—	<1	<1
15	<10	—	<1	<1
18	24	—	<1	<1
22	<1	—	<1	<1
31	<10	—	<1	<1

* Coliforms per sq cm, means of 6 carcasses

** 2.0 kJ/kg \pm 15%, 2.5 kJ/kg \pm 9 %, 5.0 kJ/kg \pm 5%

Table 6

Faecal streptococci count* of nonirradiated
and radurized chicken stored at 1.6°C

<u>Days</u> <u>Stored</u>	<u>Irradiation Dose</u>			
	<u>Nonirradiated</u>	<u>2.0kJ/kg**</u>	<u>2.5 kJ/kg**</u>	<u>5.0 kJ/kg**</u>
0	< 10	—	< 1	< 1
3	< 1	< 1	< 1	< 1
4	< 1	—	< 1	< 1
8	< 10	< 1	< 1	< 1
11	< 1	—	< 1	< 1
15	20	—	< 1	< 1
18	10	—	< 1	< 1
22	14	—	< 1	< 1
31	< 10	—	< 1	< 1

* Faecal streptococci per sq cm, means of 6 carcasses.

** 2.0 kJ/kg \pm 15%, 2.5 kJ/kg \pm 9%, 5.0 kJ/kg \pm 5%

Table 7

Odor profile of nonirradiated and radurized chicken*

stored at 1.6°C

<u>Days Stored</u>	<u>Nonirradiated</u>	<u>Irradiation Dose</u>	
		<u>2.5 kJ/kg</u>	<u>5.0 kJ/kg</u>
0	Fresh Chicken	Slight irradiation odor	Irradiation odor
4	Fresh Chicken	Fresh Chicken Odor	Slight Irradiation Odor
8	No Odor	Fresh Chicken Odor	Fresh Chicken Odor
11	Slight off odor	Chicken Odor	Chicken Odor
15	Putrid	Slight Chicken Odor	Slight Chicken Odor
18	Putrid	Stale Chicken Odor	Stale Chicken Odor
22	Putrid	Stale Chicken Odor	Stale Chicken Odor
31	Putrid	Stale Chicken (sour)	Stale Chicken Odor

* Examination of 6 carcasses

Table 8

Appearance of nonirradiated and radurized

chicken* stored at 1.6°C

<u>Days Stored</u>	<u>Irradiation Dose</u>	
	<u>Nonirradiated</u>	<u>2.5 kJ/kg</u> <u>5.0 kJ/kg</u>
0	No discoloration	Breast meat slight pink Breast meat salmon pink
4	No discoloration	Breast meat slight pink Breast meat salmon pink
8	Breast meat dull	Breast meat slight pink Breast meat salmon pink
11	Carcass dull	Breast meat slight pink Pink wings
15	Flesh decomposed	Breast meat slight pink Carcass pink
18	Flesh decomposed	Breast meat slight pink Carcass pink
22	Flesh decomposed	Meat dull Viscera brown
31	Flesh decomposed	Flesh decomposed Slight decomposition

* Examination of 6 carcasses

Table 9

Preference scores* of nonirradiated and radurized chicken
stored at 1.6°C

<u>Days Stored</u>	<u>Irradiation dose</u>					
	<u>Nonirradiated</u>		<u>2.5 kJ/kg</u>		<u>5.0 kJ/kg</u>	
	<u>White Meat</u>	<u>Dark Meat</u>	<u>White Meat</u>	<u>Dark Meat</u>	<u>White Meat</u>	<u>Dark Meat</u>
0	7.2	7.2	—	—	—	—
4	7.0	6.6	6.6	6.4	6.4	6.6
8	6.2	5.9	7.0	6.2	6.6	5.1
11	6.9	6.4	6.9	6.2	6.1	5.9
15	Spoiled	Spoiled	6.9	6.7	7.1	6.2
18	Spoiled	Spoiled	6.5	6.4	6.7	6.3
22	Spoiled	Spoiled	6.7	6.1	6.3	6.1
31	Spoiled	Spoiled	6.4	6.5	6.0	6.0

* Mean of 2 test, 8 panelists per test

Table 10

Intensity scores* of nonirradiated and radurized chicken stored at 1.6°C

Days Stored	Nonirradiated				2.5 kJ/kg				Irradiation Dose 2.0 kJ/kg			
	White		Dark		White		Dark		White		Dark	
	Rad Flav		Rad Flav		Rad Flav		Rad Flav		Rad Flav		Rad Flav	
	Mush		Mush		Mush		Mush		Mush		Mush	
0	1.0	1.9	1.0	1.6	—	—	—	—	—	—	—	—
4	1.1	1.5	1.2	1.8	1.3	1.3	1.5	1.6	1.2	1.3	1.1	1.6
8	1.6	1.3	1.3	2.1	1.3	1.4	1.1	1.8	1.4	1.1	1.9	2.1
11	1.2	1.3	1.2	1.6	1.5	1.1	1.2	1.6	1.5	1.3	1.5	1.9
15	Spoiled	Spoiled	Spoiled	Spoiled	1.1	1.4	1.1	1.6	1.1	1.1	1.2	2.7
18	Spoiled	Spoiled	Spoiled	Spoiled	1.2	1.5	1.2	2.1	1.1	1.4	1.2	1.7
22	Spoiled	Spoiled	Spoiled	Spoiled	1.2	1.1	1.5	1.7	1.4	1.4	1.6	1.8
31	Spoiled	Spoiled	Spoiled	Spoiled	1.3	1.3	1.1	1.5	1.0	1.8	1.1	2.2

* Means of 2 test, 8 panelists per test